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Novel Image based Blood Group Identification from Agglutinated Images

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Abstract*: *Detection of blood group before blood transfusion in situations of disaster or in remote areas where expert is unavailable is a challenge. Also, at present, technicians are performing blood group identification tests manually, which are prone to more human errors. Determination of the human blood types without any manual errors with less computation time in situations of emergency is the need of the hour. Here we propose a method based on processing of images that are obtained during the slide test where each of the reagents Antigen-A, Antigen-B and Antigen-D are added to the samples of blood in three separate slides. Image processing techniques such as morphological processing, and quantification of contour ring is used in determining the blood group. The images of the samples obtained after the slide test are processed and the occurrence of agglutination is evaluated. The proposed method is used to determine the blood group without any human error in emergency situation. Experimental results show that blood group identification using the proposed image processing technique gives accurate results thereby providing an alternative to microscope based identification in situations of emergency.

Index Terms*: *Blood group, Agglutination, Morphological Processing, Contour Ring

I. INTRODUCTION

It is necessary to know the blood group of a person in situations like blood transfusion and in certain emergency situations like accidents. There are two methods of determining the blood group of a person in our medical system, namely, plate method and card method. In the plate method, blood sample taken from a person are placed in three slides to which reagents Antigen-A, Antigen-B and Antigen-D are added respectively. The mixture is then observed for agglutination formation. In the card method, the sample of the blood is mixed with the content of the micro-tube and then subjected to centrifugation for 30 minutes. Though the interpreted result is accurate, the processing time is more [1]. Currently identifying the blood group in emergency situation or in remote area requires moving laboratory, which will delay the task of identifying the blood group. Moreover, O-blood group which is considered as universal donor is administered in these situations. But sometimes, due to incompatibility, administering O-blood group may lead to death of the patient. Also, manual pre-transfusion tests performed by technicians, may sometimes result in errors which may lead to fatal consequences. As a result, it is vital to find out methods for automating the process of determining the blood group of a person.

Image processing techniques have found its way in a number of applications including medical and security fields and has been the primely sought after technique for automating biometric detection, recognition and identification. Numerous researches have been carried out in face recognition, finger print recognition, iris recognition etc., using image processing techniques. But little has been done in blood group identification using image processing. In [2] the authors have developed an automated blood group identification using image processing techniques where they have applied Local Binary Pattern and Histogram comparison for feature extraction and classified the blood group using SVM classifier. In [1], the authors have estimated the standard deviation of the image obtained from slide test after addition of reagents to blood samples. Based on the standard deviation values they have classified the blood group as A, B, AB, O. In [3], authors used SIFT features and SVM classifier to identify blood group using image processing techniques. Also, the authors have used Niblack's algorithm to calculate pixel-wise threshold wherein a rectangular window is slided over the gray scale image. They used the local mean and the standard deviation of all the pixels in the window to calculate the threshold.

In [4], authors have used image processing techniques to classify the blood group based on the standard deviation value of the HSL plane extracted image. In [5] in addition to determining the blood group of the person using image processing the authors have also developed a system to estimate the Red Blood cell count of the person using Hough transform. In [6], authors present a method where the color image acquired using a digital camera is uploaded into MATLAB application and is converted to HSV format. After thresholding operation, derivative of histogram image is taken for identifying the blood area and classifying the blood group. The principle that optical property of blood varies for different antigen present on the RBC is used [7] to determine the blood group. The authors [8] have used blob detection in morphological processed image of the slide test to determine the blood group of a person. In [9], the authors used area, mean, standard deviation as quantifying measure for determining the blood group from the HSL plane extracted image.

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They obtained a sensitivity of 0.86, specificity of 0.13 and a precision of 86%.

A non-invasive method of identifying blood group has been proposed in [10] where images of capillaries underneath the skin are captured optically and Multi-Wavelength Light (MWL) scattering method is used in classifying blood cells based on specific antigens on the Red Blood Cell (RBC) surface. But this requires optical source and optical detectors in detecting the antigens on RBC. In [11], area, mean, standard deviation, minimal and maximal values of the image of the mixture serums are analyzed using IMAQ Vision software from National Instruments, to identify the blood type. In [12], pattern and geometric matching are used in determining the blood type.

The aim of the proposed system is to develop a methodology to automatically categorize different blood group with less processing time and more accuracy, using sample images acquired from slide test. The system would help in reducing the risks that results because of human error. The system is developed using image processing techniques in MATLAB. Images obtained from slide tests are processed and detected for the presence of agglutination. Some of the image processing techniques are binary conversion of images and morphological operations which include dilation, erosion and identification of connected components.

II. METHODOLOGY

The identification of blood group is based on the concept of agglutination reaction. Agglutination of red cells occurs due to the reaction of the red cell antigens and the corresponding antibody. Positive agglutination is observed when clumps of red cells are seen during the slide test or by the formation of buttons in test tube. Uniform distribution of red cells during slide test on slide or absence of button formation in test tube indicates negative agglutination. Fig. 1 shows the steps involved in identification of blood group in the conventional lab test method.

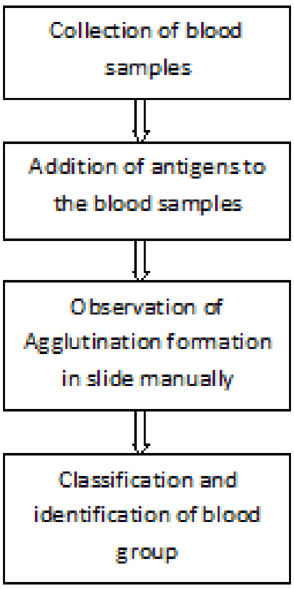
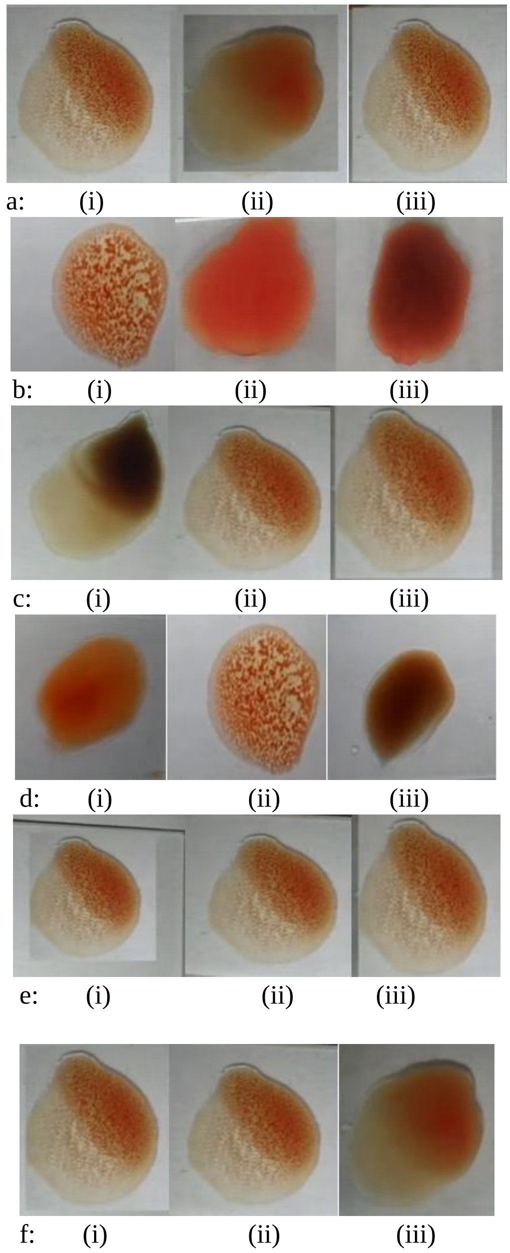
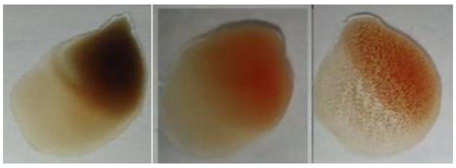


Fig.1: General method of determining blood group

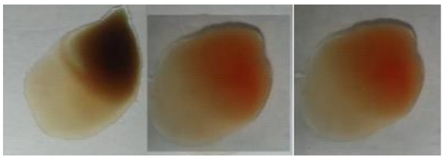
In order to identify the blood group of a person, Antigen-A, Antigen-B, Antigen-D are added with blood samples of the person. These added antigens may or may not mix with antibodies of red blood cells of particular blood group. The technician in the lab observes for blood cell clumps after addition of antigens to the blood samples. For example, if clumps are observed in samples added with antigen-A and that added with antigen-D, the blood group is identified as A-positive blood type. If clumps are observed only in samples added with antigen-A then the group is identified as A-Negative. Similarly, if when clumps are formed in blood samples added with antigen-B and that with antigen-D then the group is identified as B-Positive. If no clumps are formed in blood samples added with any of the antigens A, B or D, then the group is identified as O-Negative.

Images of a blood sample of blood group A-Positive, A-Negative, B-Positive, B-Negative, O-Positive, O-Negative, AB-Positive and AB-Negative added with antigens A, B and D are shown in Fig. 2a-h respectively.





g: (i) (ii) (iii)



h: (i) (ii) (iii)

Fig. 2a-h: Blood samples of A-Positive, A-Negative, B-Positive, B-Negative, O-Positive, O-Negative, AB-Positive, AB-Negative blood groups with (i) antigen-A (ii) antigen-B (iii) antigen-D reagents

Table 1 summarizes the blood group classification based on the presence of clumps after addition of antigens with the blood sample.

Table 1: Classification of blood groups

Antigen A	Antigen B	Antigen D	Blood Group
Present	Absent	Present	A positive
Present	Absent	Absent	A negative
Absent	Present	Present	B positive
Absent	Present	Absent	B negative
Present	Present	Present	AB positive
Present	Present	Absent	AB negative
Absent	Absent	Present	O positive
Absent	Absent	Absent	O negative

III. PROPOSED METHODOLOGY

An image processing based blood group identification from blood samples has been proposed to reduce errors due to manual identification. Blood group is identified based on number of contours in the image obtained after adding antigens to the blood sample. Image processing techniques are applied to the image captured when antigen A, antigen-B, antigen D are added to the blood sample respectively. Fig. 3 shows the steps involved in identifying the number of contours in the agglutination formed image.

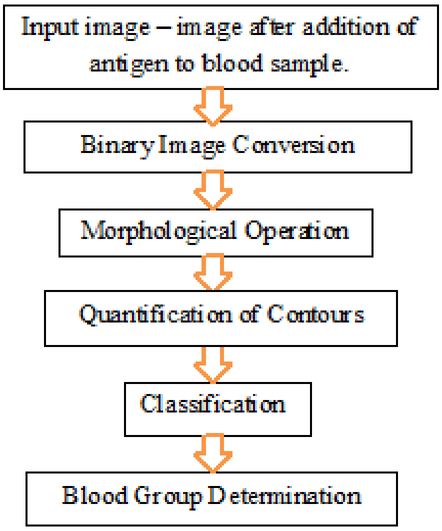


Fig. 3: Flow chart for Blood Group Identification using Image Processing

A. Binary Conversion

A grayscale image is converted to a binary image where each pixel can take up either a 0 or 1 corresponding to black and white colours respectively. The basic principle involved in binary conversion is thresholding. Otsu's method of thresholding is used here. This is done by replacing all pixel in the input image whose luminance value is greater than the threshold level, with the value 1 corresponding to white and replacing all other pixels with the value 0 corresponding to black.

B. Morphological Operation

Binary images are susceptible to numerous imperfections. In particular, the binary regions that results out of simple thresholding are distorted by noise and texture. Morphological image processing involves a collection of non-linear operations that are related to the shape or morphology of features in an image and performs the task of eliminating imperfections by accounting for the form and structure of the image. It includes operations such as "dilation, erosion, morphological filtering and granulometry" which can be carried out either in pre-processing or post-processing stages to eliminate noise spikes and ragged edges. During the process of erosion, the size of the objects reduces uniformly in relation to the background whereas the reverse operation takes place during dilation. Dilation corresponds to opening operation and erosion corresponds to closing operation. Closing operation involves filling the holes and gaps. It is the process of dilation which is followed by erosion. The operations used in this are labelling and counting number of contours in the image. The connected components may be either 4 connected or 8 connected components.

IV. EXPERIMENTAL RESULTS

Sample images obtained after addition of antigen-A, antigen-B and antigen-D respectively to the blood samples are given as input to the blood group identification system. The image is then subjected to pre-processing such as colour image to gray scale image conversion. The gray scale image is then converted to Binary image by Otsu's thresholding. The processed image is then subjected to morphological operations such as dilation and corrosion to remove artifacts. The number of connected components is obtained to know the number of agglutination components formed. Based on the number of contours formed the blood group is identified. Fig. 4 shows sample input images obtained from Slide test after addition of antigens-A, antigen-B and antigen-D to the blood sample and Fig. 5 shows the Binary image for the sample shown in Fig. 4.

Fig. 4: Input images obtained from Slide test after addition of antigen-A, antigen-B and antigen-D to blood sample

Fig. 5: Binary image obtained after Otsu's thresholding for the given input image shown in Fig. 4

Here 8-connected components are considered. The elements of labelled matrix are integer values greater than or equal to 0. The pixels labelled 0 are the background. The pixels labelled 1 form one object, the pixels labelled 2 form the second object, and so on. Fig. 6 shows the screen shot image of the result of MATLAB program for determining the number of contours after addition of antigens to the blood sample image (agglutinated image).

Matlab Results:

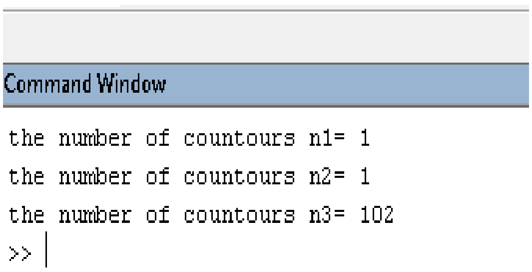


Fig. 6: Number of contours observed with antigen-A (n1), antigen-B(n2) and antigen-D(n3) for the given input image

Classification:

Classification of blood groups is done based on the number of connected components i.e.; the number of contours in the image. If the numbers of contours are below 5, then image is classified as non-agglutinated image. If the number of contours is above 5, then image is classified as agglutinated image. The blood group is determined based on the criteria given in Table 1. Table 2 shows the classification of blood group based on number of contours for 8 blood group samples.

The test results for each type of blood group when added with antigen-A, antigen-B and antigen-D are summarized in Table 2. The results show that the blood group detected using the proposed system matches with the ground truth result.

Table 2: Number of connected components detected in agglutinated image

Actual blood group	No of connected components with antigen-B added	No of connected components with antigen-B added	No of connected components with antigen-B added	Blood group detected
B-VE	2	102	1	B-VE
B+VE	2	9	10	B+VE
AB+VE	10	11	12	AB+VE
AB-VE	10	10	2	AB-VE
O+VE	1	1	85	O+VE
O-VE	2	1	5	O-VE
A-VE	21	1	3	A-VE
A+VE	23	1	28	A+VE

The dataset contains total of 80 images that are taken from the manually tested blood samples whose blood group are known already. In this dataset 10 images from each blood group type are taken. Images are processed through the proposed system and tested to check if the results match with manually generated results or not.

V. CONCLUSION

The proposed methodology of determining the blood group from agglutinated blood sample images involves image processing technique. The images obtained after the addition of antigens with blood samples is capable of detecting the type of blood group accurately based on the number of contours formed. In future, in addition to determining the blood group, detection of blood sugar level using image processing technique will be carried out and an effective system would be proposed.

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